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Distal capitate shortening with capitometacarpal arthrodesis for treatment of early stages of Kienböck's disease

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Abstract
Background: Kienböck's disease presents challenges in wrist management, with varying effectiveness of surgical interventions depending on disease stage. This study evaluates distal capitate shortening combined with capitometacarpal arthrodesis in patients with stage II and IIIA Kienböck's disease.
Methods: Patients were classified into stage II and IIIA based on radiographic findings and treated with the aforementioned surgical technique. Postoperative outcomes were measured in terms of pain relief, range of motion (ROM), grip strength, and Modified Mayo Wrist Score (MMWS). Statistical comparisons were made between the stages.
Results: For stage II patients, significant improvements were noted: pain score reduced by 40% ($p< 0.01$), ROM increased by 25% ($p< 0.01$), grip strength enhanced by 30% ($p< 0.05$), and MMWS improved by 35 points ($p< 0.01$). In stage IIIA patients, pain relief was only 15% ($p = 0.12$), ROM improved by 10% ($p = 0.23$), grip strength by 12% ($p = 0.18$), and MMWS by 10 points ($p = 0.22$). Failure rates were higher in stage IIIA, with 40% showing unsatisfactory outcomes.
Conclusion: Distal capitate shortening combined with capitometacarpal arthrodesis is effective for stage II Kienböck's disease, significantly improving postoperative outcomes. However, the technique is less effective for stage IIIA, with high failure rates and limited symptom relief. The lunate height ratio may be a useful prognostic indicator for surgical success.

Keywords: Kienböck's, capitate shortening, capitometacarpal arthrodesis

Introduction
Kienböck's disease, a pathology involving the lunate bone, arises from avascular, aseptic necrosis [1]. Clinically, it characteristically manifests with wrist pain, restricted motion, and diminished strength due to the predictable sequence of lunate fragmentation, subsequent carpal instability, and eventual carpal collapse [2].
This condition predominantly impacts adults aged 20 to 40 years, especially male manual laborers, and it generally presents unilaterally. Both wrists are equally susceptible, with many patients recalling a specific traumatic incident occurring months or even years prior to diagnosis [3].
For staging and therapeutic decision-making in Kienböck's disease, plain radiographs are fundamental, with Lichtman's modification of Stahl's classification being the most extensively utilized [4].
Tomographic imaging can be instrumental in accurately assessing the full extent of the pathology, frequently leading to the reclassification of patients from stage II to stage III by providing a clearer depiction of bone collapse. While bone scintigraphy may be useful in ruling out Kienböck's disease, its lack of specificity renders it insufficient to distinguish among the various other etiologies that may contribute to increased radiotracer uptake in the lunate region [5].
Magnetic resonance imaging (MRI) proves particularly valuable in the early stages of the disease, especially when conventional radiographs fail to provide a definitive diagnosis. Both T1- and T2-weighted sequences typically exhibit reduced signal intensity. MRI stands out as an exceptionally sensitive and specific modality for identifying marrow alterations indicative of osteonecrosis. Additionally, MRI has been employed to indirectly observe revascularization post-surgical intervention [6].

The management of Kienböck's disease continues to provoke debate within the medical community. Given the hypothesis that Kienböck's disease may stem from excessive mechanical stress on the bone, research has focused on exploring strategies to alleviate the load on the lunate [7].

The principal indication for surgical intervention in Kienböck's disease arises from enduring pain unresponsive to conservative measures, including nonsteroidal anti-inflammatory drugs (NSAIDs) and immobilization. Patients presenting with moderate to severe symptoms typically qualify for operative treatment. The selection of the surgical approach is contingent upon several factors, such as the patient's age, the stage of the disease, and the presence or absence of ulnar variance (47) [8].

In cases of symptomatic Kienböck's disease at stages III to IV, where the scaphoid has already adopted a flexed posture, revascularization procedures become unsuitable. For these advanced stages, recommended salvage interventions include tendon ball arthroplasty, selective inter-carpal arthrodesis, proximal row carpectomy, or wrist denervation. Biomechanical research indicates that scaphocapitate (SC) arthrodesis redistributes mechanical loads by redirecting forces from the radiolunate joint to the radioscaphoid joint, thereby altering the force transmission through the hand and wrist [9].

This study aims to assess the efficacy of a surgical approach that integrates distal capitate shortening with arthrodesis to the third metacarpal base in addressing early-stage Kienböck's disease (stages II and IIIA) in patients with neutral ulnar variance. The study aims to determine whether this technique provides pain relief, enhances wrist mobility, or leads to notable changes in radiographic outcomes.

Methods

This prospective study carried out on 20 patients attending the outpatient clinic of orthopedic surgery in Benha university hospitals with early stages (stages II and IIIA) of Kienböck's disease with neutral ulnar variance who complying with the following inclusion and exclusion criteria. Patients that participated during period from 1 August 2022 to 1 January 2023 and all the patients were followed up for 12-18 months. Upon securing approval from the Institutional Ethical Committee of the Faculty of Medicine Benha University and obtaining informed consent from each patient.

Inclusion criteria

Patients aged 18 to 60 years, diagnosed with stage II or IIIA Kienböck's disease as per the Lichtman classification, and exhibiting normal ulnar variance, who meet the following criteria:

1. Patients with history of chronic wrist pain diagnosed as Kienbock's disease stage II and IIIA according to Lichtman's classification.
2. Skeletally mature adults.
3. Generally active.
4. Both sexes.
5. With no previous history of carpal or radio-carpal procedures.

Exclusion criteria

Patients with

- Skeletally immature patients.
- Bilateral disease.
- Previous wrist surgery.
- Previous wrist joint disease.
- Have wrist problems on the contralateral side.

Operative Technique

The patient was placed supine on the operating-room table with the arm extended on an arm radiolucent table. Operation was performed under general anesthesia and a broad spectrum antibiotic was administered IV to the patient. A pneumatic tourniquet was applied high on the upper affected arm and was elevated to 100 mmHg above the patient's systolic blood pressure to obtain a bloodless operative field. Double sterilization for the affected arm from level of tourniquet distal to the fingers by betadine then sterilium.

A 3-cm longitudinal dorsal incision was made along the midline, centered over the capitometacarpal joint. The tendons within the 4th compartment were carefully retracted toward the ulnar side, followed by a longitudinal incision of the capsule to expose the capitometacarpal joint. Fluoroscopy was routinely employed to accurately locate the joint. Using a fine oscillating saw, a wafer of bone and cartilage, measuring 1.0–1.5 mm, was excised from the distal capitate, with a corresponding wafer removed from the base of the 3rd metacarpal, creating a defect of 2–3 mm. To avoid damaging the flexor tendons on the palmar surface, the saw cuts were completed with small osteotomes. The bone surfaces of the capitate and the 3rd metacarpal were then compressed with reduction forceps and secured using a low-profile miniplate and screws. The wound was meticulously closed over the approximated capsule and the 4th extensor compartment, followed by immobilization of the wrist with a short arm volar splint.

Post-operative care

- Active fingers motion started immediately after surgery.
- After two weeks, the stitches were removed wrist joint motion will be allowed 6 weeks after surgery.
- Active-assisted and passive wrist joint mobilization will be maintained under the guidance of a highly specialized physiotherapist until full osseous union is confirmed. This union is radiologically defined as solid fusion, indicated by the presence of a bony bridge spanning at least 80% of the arthrodesis site in two orthogonal X-ray views.
- Resistance exercises were initiated only after the achievement of complete union.

Follow-up

- All the patients will be followed up for 12-18 months.
- Patients were followed up at 1 week, 2 weeks, 1 month, every 2 weeks until capitometacarpal arthrodesis was achieved and then every 2 months during the follow-up period.
- Complications (infection, persistent pain after surgery, loss of reduction, transient paraesthesia, mal-union and non-union) were recorded.

Results

The study recruited 20 patients who were sub-classified according to lichtmans class into 10 patients of Stage II, and another 10 patients of Stage IIIA.

Demographic and clinical parameters

The mean age of patients with Stage II was 45.9± 9.3 and for Stage IIIA it was 44.7 ± 9.4 and the relation was non-significant. Similarly, No statistically significant difference between both groups regarding sex distribution, with male predominance in both of them (Table 1).As regard clinical parameters, 30.0% of both groups suffered from HTN or DM (Table 1).Both groups were matched for age, sex and other clinical parameters. The commonest side of injury was right side 65.0%, and the majority of them the cause of injury was idiopathic (Table 1).

Table 1: Demographic and clinical parameters between the studied groups

Parameters	Total, n=20	Stage II, n=10	Stage IIIA, n=10	p value
Demographic data				
Age, mean ± SD	45.9±9.3	47.0±9.6	44.7±9.4	0.595ŧ
Sex, n (%)				
Male	14 (70.0)	6 (60.0)	8 (80.0)	0.628 ŧŧŧ
Female	6 (30.0)	4 (40.0)	2 (20.0)	
Clinical parameters				
Hypertension, n (%)	5 (25.0)	2 (20.0)	3 (30.0)	1.0 ŧŧŧ
Diabetes Mellitus, n (%)	5 (25.0)	2 (20.0)	3 (30.0)	1.0ŧŧŧ
Details of injury				
Side of injury, n (%)				
Rt	13 (65.0)	6 (60.0)	7 (70.0)	1.0 ŧŧŧ
Lt	7 (35.0)	4 (40.0)	3 (30.0)	
Mechanism of injury, n (%)				
Idiopathic	14 (70.0)	7 (70.0)	7 (70.0)	0.721 ŧŧŧ
lifting heavy objects	2 (20.0)	1 (10.0)	1 (10.0)	
Repeated wrist sprain	1 (10.0)	1 (10.0)	0 (0.0)	
old colle's fracture	1 (10.0)	1 (10.0)	0 (0.0)	
Fall or trauma	2 (20.0)	0 (0.0)	2 (20.0)	

Clinical and Radiographic profile of participants (Stage II) preoperatively

The mean VAS was 58.5 mm and ranged between 40mm to 75 mm, while the mean ROM was 56.3% and ranged between 43% to 64%. The mean Grip strength, Carpal Height Index, and Lunate Height Index were 48.0%, 0.5, and 0.52 respectively. The mean SC Angle was 32.3, while the mean SL Angle was 49.0. The mean MMWS among studied patients was 52.0, while the range was 40 to 60 (Table 2).

Table (2): Preoperative Clinical and Radiographic Parameters for Stage II Group, (n=10)

Patient ID	VAS (mm)	ROM (%)	Grip strength (%)	Carpal Height Index	Lunate Height Index	SC Angle	SL Angle	MMWS
1	40	55	50	.50	.50	30	45	55
2	50	60	45	.51	.53	32	45	60
3	60	50	30	.51	.52	33	46	40
4	40	62	35	.50	.51	32	48	60
5	60	54	40	.51	.50	33	52	45
6	60	52	45	.50	.53	32	54	60
7	60	63	50	.50	.53	35	48	55
8	75	64	60	.50	.52	31	49	50
9	65	60	60	.50	.52	33	50	50
10	75	43	65	.50	.52	32	53	45
Range	40-75	43-64	30-65	0.50-0.51	0.50-0.53	30-35	45-54	40-60
Mean	58.5	56.3	48.0	0.50	0.52	32.3	49.0	52.0

Clinical and Radiographic profile of participants (Stage IIIA) preoperatively

The mean VAS was 59.0 mm and ranged between 40 mm to 75mm, while the mean ROM was 49.5% and ranged between 40% to 60%. The mean Grip strength, Carpal Height Index, and Lunate Height Index were 44.5%, 0.5, and 0.46 respectively. The mean SC Angle was 31.8, while the mean SL Angle was 50.5. The mean MMWS among studied patients was 36.0, while the range was 25 to 50 (Table 3).

Clinical and Radiographic profile of participants (Stage II) postoperatively: The mean VAS was 1.9, while the mean ROM was 74.9. The mean grip strength was 75.2, while the mean Carpal Height Index was 0.5. Morever, the mean Lunate Height Index 0.51, while the mean SC angle was 32.0. The mean SL angle was was 47.9 while the mean MMWS was 79.5 (Table 4).

Clinical and Radiographic profile of participants (Stage IIIA) post-operatively

The mean VAS was 54.8, while the mean ROM was 51.6. The mean grip strength was 48.0, while the mean Carpal Height Index was 0.39. Moreover, the mean lunate height index 0.4, while the mean SC angle was 18.8. The mean SL angle was 70.5 while the mean MMWS was 46.5 (Table 5).

Table 3: Preoperative Clinical and Radiographic Parameters for Stage IIIA Group, (n=10)

Patient ID	VAS (mm)	ROM (%)	Grip strength (%)	Carpal Height Index	Lunate Height Index	SC Angle	SL Angle	MMWS
1	50	60	45	.50	.40	30	45	50
2	64	55	50	.51	.45	32	49	45
3	58	50	55	.50	.43	30	55	40
4	75	50	40	.50	.48	31	57	35
5	65	55	50	.50	.46	34	53	30
6	60	40	45	.50	.47	31	50	30
7	68	50	35	.50	.45	32	48	25
8	50	45	40	.50	.49	34	50	30
9	40	50	45	.51	.45	32	48	45
10	60	40	40	.50	.49	32	50	30
Range	40-75	40-60	35-55	0.50-0.51	0.40-0.49	30-34	45-57	25-50
Mean	59.0	49.5	44.5	0.50	0.46	31.8	50.5	36.0

Table 4: Postoperative Clinical and Radiographic Parameters for Stage II Group, (n=10)

Patient ID	VAS (mm)	ROM (%)	Grip strength (%)	Carpal Height Index	Lunate Height Index	SC Angle	SL Angle	MMWS
1	0	75	85	.50	.52	30	46	80
2	0	70	75	.50	.50	32	48	85
3	0	80	70	.50	.51	33	47	80
4	0	73	80	.50	.51	31	45	80
5	2	75	78	.49	.50	32	55	75
6	0	76	70	.51	.50	32	45	80
7	0	65	76	.50	.50	35	47	70
8	10	74	75	.50	.50	31	48	85
9	5	76	73	.51	.52	32	49	80
10	2	85	70	.51	.50	32	49	80
Range	0-10	65-85	70-85	0.49-0.51	0.50-0.52	30-35	45-55	70-85
Mean	1.9	74.9	75.2	0.50	0.51	32.0	47.9	79.5

Table 5: Postoperative Clinical and Radiographic Parameters for Stage IIIA Group.

Patient ID	VAS (mm)	ROM (%)	Grip strength (%)	Carpal Height Index	Lunate Height Index	SC Angle	SL Angle	MMWS
1	50	65	55	.40	.43	24	75	45
2	50	60	60	.40	.35	25	60	50
3	60	55	40	.39	.36	26	75	30
4	71	40	48	.39	.40	17	62	65
5	45	43	47	.40	.42	16	70	30
6	60	42	55	.40	.40	25	75	60
7	67	46	45	.40	.43	13	72	60
8	50	55	40	.40	.42	12	69	30
9	35	60	50	.40	.34	16	69	60
10	60	50	40	.28	.45	14	78	35
Range	35-71	40-65	40-60	0.28-0.40	0.34-0.45	12-26	60-78	30-65
Mean	54.8	51.6	48.0	0.39	0.40	18.8	70.5	46.5

Clinical and Radiographic profile of participants (Stage II) pre Vs post-operative

For Stage II group, the VAS score had significantly decreased from 58.5 preoperatively to 1.9 postoperatively (p<0.001) (Table 6).Similarly, the ROM had significantly increased from 56.3 to 74.9 after operation (Table 6).Grip strength had significantly increased postoperatively, compared with the preoperative mean (Table 6).None of Carpal Height Index , Lunate Height Index, SC Angle, or SL Angle showed any difference postoperatively, compared with the pre-operative period (Table 6).There was a statistically significant difference in MMWS before and after operation, It significantly increased from 52.0 preoperatively to 79.5 postoperatively (Table 6).

Table 6: Changes in Parameters Before to After Surgery for Stage II Group.

Parameter	Pre-operative		Post-operative		p-value	Percent change
	Mean ± SD	Range	Mean ± SD	Range		
VAS (mm)	58.5±12.3	40-75	1.9±3.3	0-10	<0.001*	97.3%
ROM (%)	56.3±6.7	43-64	74.9±5.3	65-85	<0.001*	35.0%
Grip strength (%)	48.0±11.4	30-65	75.2±4.9	70-85	<0.001*	65.5%
Carpal Height Index	0.50±0.0	0.50-0.51	0.50±0.0	0.49-0.51	0.758	0.2%
Lunate Height Index	0.52±0.0	0.50-0.53	0.51±0.0	0.50-0.52	0.051	2.3%
SC Angle	32.3±1.3	30-35	32.0±1.3	30-33	0.081	0.9%
SL Angle	49.0±3.2	45-54	47.9±2.9	45-55	0.360	2.0%
MMWS	52.0±7.1	40-60	79.5±4.4	70-85	<0.001*	55.6%

Clinical and Radiographic profile of participants (Stage IIIA) pre- Vs post-operative

Group Stage IIIA patients, showed no significant improvement in VAS, ROM or Grip strength (p>0.05) (Table 7). Carpal Height Index showed significant decrease in postoperative period compared with preoperatively (p<0.001) (Table 7). Also, Lunate Height Index showed significant decrease in postoperative period compared with preoperatively (p=0.002) (Table 8, figure 43).SC Angle had significantly decreased from 31.8 to 18.8 after surgery (p<0.001) (Table 7). Moreover, SL Angle exhibited a significant increase from 50.5 preoperatively to 70.5 postoperatively (Table 7). On contrary, MMWS didn't show any significant improvement after surgery (Table 7).

Table 7: Changes in Parameters Before to After Surgery for Stage IIIA Group, (n=10)

Parameter	Pre-operative		Post-operative		p-value⊦	Percent change
	Mean ± SD	Range	Mean ± SD	Range		
VAS (mm)	59.0±10.1	40-75	54.8±10.8	35-71	0.098	6.9%
ROM (%)	49.5±6.4	40-60	51.6±8.7	40-65	0.435	5.0%
Grip strength (%)	44.5±6.0	35-55	48.0±7.1	40-60	0.208	9.1%
Carpal Height Index	0.50±0.0	0.50-0.51	0.39±0.0	0.23-0.40	<0.001	23.1%
Lunate Height Index	0.46±0.0	0.40-0.49	0.40±0.0	0.34-0.45	0.002	12.3%
SC Angle	31.8±1.4	30-34	18.8±5.6	12-26	<0.001	40.3%
SL Angle	50.5±3.6	45-57	70.5±5.8	60-78	<0.001	40.4%
MMWS	36.0±8.4	25-50	46.5±14.3	30-65	0.069	35.2%

Correlations of the Postoperative VAS to the Radiographic Parameters for both groups

A statistically significant negative association between VAS with Carpal Height Index (r=-0904, p<0.001), Lunate Height Index (r=-0.821, p <0.001), and SC Angle (r=-0.832, p<0.001) (Table 9, figure 47-49)

Table 8: Correlations of the Postoperative VAS to the Radiographic Parameters for both groups, (n=20)

Parameters	VAS	
	r⊦	p-value
Carpal Height Index	-0.904	<0.001*
Lunate Height Index	-0.821	<0.001*
SC Angle	-0.832	<0.001*
SL Angle	0.312	0.180

Correlations of the Postoperative ROM to the Radiographic Parameters for both groups.

Also, A statistically significant positive association between ROM with Carpal Height Index (r=0.807, p<0.001), Lunate Height Index (r=0.723, p <0.001), and SC Angle (r=0.798, p<0.001) (Table 9).

Table 9: Correlations of the Postoperative ROM to the Radiographic Parameters for both groups, (n=20)

Parameters	ROM	
	r⊦	p-value
Carpal Height Index	0.807	<0.001*
Lunate Height Index	0.723	<0.001*
SC Angle	0.798	<0.001*
SL Angle	-0.424	0.062

Correlations of the Postoperative grip strength to the Radiographic Parameters for both groups

Grip strength showed a statistically significant positive correlation with Carpal Height Index (r=0.891, p<0.001), Lunate Height Index (r=0.786, p<0.001), and SC Angle (r=0.875, p<0.001) (Table 10).

Correlations of the Postoperative MMWS to the Radiographic Parameters for both groups

MMWS showed a statistically significant positive association between MMWS with Carpal Height Index (r=0.840, p<0.001), Lunate Height Index (r=0.716, p<0.001), and SC Angle (r=0.741, p<0.001) (Table 11).

Table 10: Correlations of the Postoperative grip strength to the Radiographic Parameters for both groups, (n=20)

Parameters	Grip	
	r⊦	p-value
Carpal Height Index	0.891	<0.001*
Lunate Height Index	0.786	<0.001*
SC Angle	0.875	<0.001*
SL Angle	-0.369	0.110

Table 11: Correlations of the Postoperative MMWS to the Radiographic Parameters for both groups, (n=20)

Parameters	MMWS	
	r⊦	p-value
Carpal Height Index	0.840	<0.001*
Lunate Height Index	0.716	<0.001*
SC Angle	0.741	<0.001*
SL Angle	-0.254	0.281

Case Presentation

Fourty two years old male, manual worker, medically free presented to Benha university hospital complaining of idiopathic pain, swelling, limitation of movement at left non-dominant wrist without any history of trauma or sprain. He was diagnosed Kienböck's type II on litchman classification. Distal capitate shortening and arthrodesis to the base of the 3rd metacarpal was done using low profile miniplate and screws.

Follow up

- He was followed up for 18 months after surgery.
- Time of full union 10 weeks.
- The end functional result was excellent.
- There were no complications.

Fig 1: Pre-operative plain x ray (PA & LAT)

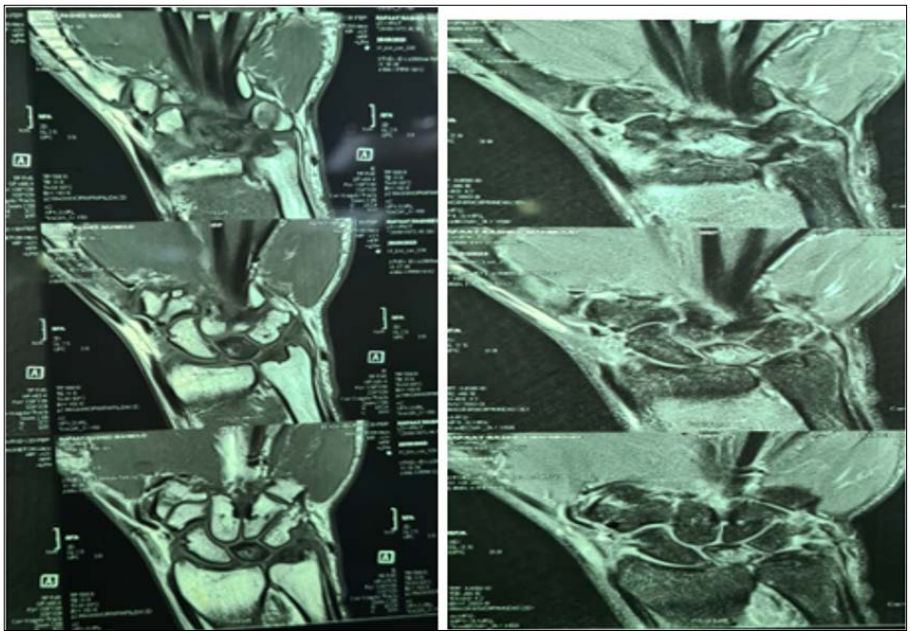

Fig 2: Pre-operative MRI showing kienbock type II.

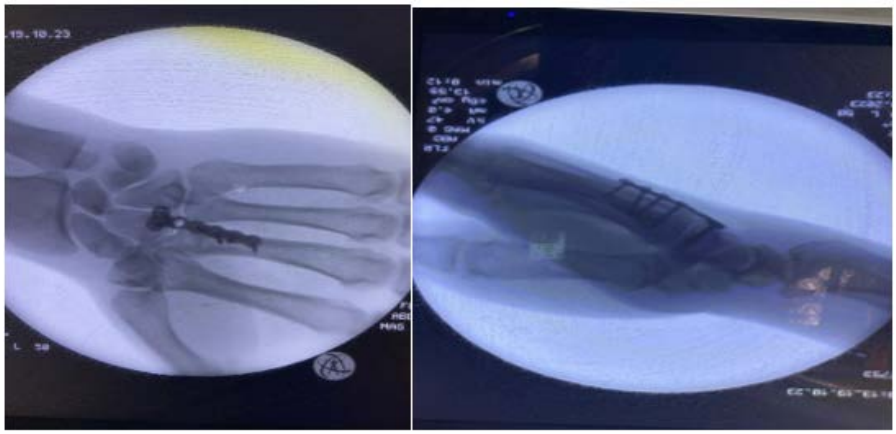

Fig 3: AP & Lat intraoperative fluoroscopy.

Fig 4: AP & Lat views post-operative after fusion.

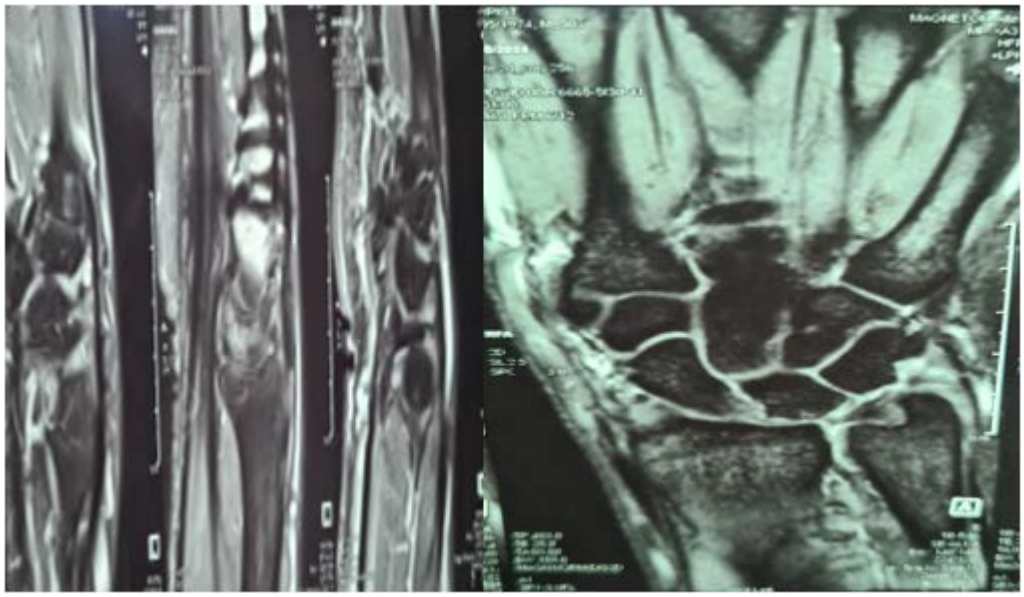

Fig 5: MRI 12 months' post-operative showing better lunate revascularization.

Fig 6: Pre-operative ROM (flexion & extension).

Fig 7: 18 Months post-operative ROM (flexion & extension).

Discussion

The management of Kienböck's disease encompasses a diverse spectrum of therapeutic strategies, extending from conservative approaches such as immobilization to an array of surgical techniques tailored to the disease's progression. The management strategies encompass methods such as lunate off-loading, joint leveling operations, lunate revascularization, and an array of salvage techniques, all meticulously tailored to correspond with the specific disease stage being addressed. For patients exhibiting advanced stages or neutral ulnar variance, limited wrist arthrodesis (LWA) options, such as STT or SCA with preservation of the lunate, offer a viable solution. Additionally, LWA serves as a salvage procedure that maintains wrist motion in cases where the lunate has been fractured, especially when the lunate's cartilage integrity is compromised or when chondral degeneration at the capitate head precludes the feasibility of proximal row carpectomy (PRC) [11].

The underlying rationale for employing distal capitate shortening combined with arthrodesis to the third metacarpal base is to effectively diminish the load exerted on the lunate, thus preventing the proximal migration of the capitate bone. By implementing shortening of the capitate, the procedure effectively mitigates the pressure exerted on the lunate, while the arthrodesis between the capitate and the third metacarpal base serves to stabilize the capitate, thereby inhibiting its proximal migration and averting subsequent carpal collapse [12].

The osteotomy technique exploits the vascular network surrounding the capitate bone. Recent research suggests that the proximal portion of the capitate is nourished by a branch of the anterior interosseous artery. Accordingly, it is recommended that the osteotomy be performed approximately 2 mm from the distal capitate surface [13].

Anatomical assessments have shown a marked reduction in the load borne by the lunate across all specimens following capitate shortening, especially in instances of neutral ulnar variance. This reduction in pressure was closely associated with an increased angulation between the capitate and scaphoid bones [14].

Stabilization is further enhanced by fusing the base of the third metacarpal with the distal capitate, as the third metacarpal—being the most stable and least mobile of the metacarpals—significantly contributes to this effect. The distal carpal row functions as a rigid component of the hand due to the nearly immovable ligamentous connection between the capitate and the third metacarpal base, combined with the minimal movement observed between these bones [15].

Numerous studies have assessed isolated capitate shortening osteotomy outcomes. One study with 11 cases of moderate Kienböck's disease (stages I to IIIA) reported six excellent, two satisfactory, and three suboptimal outcomes [16]. Another study found that seven patients in stages II and IIIA returned to work within six months post-surgery, with all reporting high satisfaction and satisfactory results in range of motion, grip strength, and pinch strength. MRI confirmed successful lunate revascularization in six out of ten patients (three in stage II and seven in stage III) [18].

Fouly *et al.* [12] achieved complete pain relief in eight stage II and four stage IIIA patients using the same surgical technique, with significant improvements in grip strength and range of motion (80% to 100% of the unaffected wrist). Five patients had outstanding outcomes, and seven were rated as satisfactory by the Modified Mayo Wrist Score (MMWS), with no unsatisfactory results. The study found that distal capitate shortening and arthrodesis effectively prevented carpal collapse and increased carpal height, aligning with our findings.

Hegazy *et al.* [19] also reported improvements in pain, grip strength, range of motion, and MMWS in stage II patients. However, six stage IIIA patients experienced only partial pain relief, requiring ongoing analgesics, and four needed further surgery. The study attributed lower MMWS in stage IIIA patients to radiological differences, concluding that this surgical approach is not recommended for stage IIIA Kienböck's disease.

Al-Ashhab *et al.* [20] reported significant improvements in postoperative pain, range of motion, grasp strength, and MMWS among stage II Kienböck's disease patients using the same technique. However, stage IIIA patients experienced only partial pain relief, with stage II patients achieving higher postoperative clinical scores. The study concluded that combining capitometacarpal arthrodesis with distal capitate shortening effectively reduces pain, maintains range of motion, and improves grip strength in stage II patients.

In our study, we observed significant improvements in pain, range of motion, grip strength, and MMWS in stage II Kienböck's disease patients, consistent with the findings of Fouly *et al.* [12], Hegazy *et al.* [19], and Al-Ashhab *et al.* [20]. However, most stage IIIA patients did not achieve full pain relief, with six requiring NSAIDs and four needing revision surgery. These results align with Hegazy *et al.* [19] and Al-Ashhab *et al.* [20] but contrast with Fouly *et al.* [12]. Postoperative radiographs revealed persistent carpal collapse in stage IIIA patients, reflecting the procedure's limitations in preventing proximal capitate migration. The

reduced MMWS in stage IIIA patients was linked to radiographic differences compared to stage II. We propose that the lunate height ratio could be a prognostic marker to distinguish between stage II and IIIA, with normal ratios in stage II patients potentially leading to better outcomes. In contrast, stage IIIA patients with reduced lunate height ratios experienced further carpal collapse and decreased carpal height post-surgery, contributing to poorer clinical outcomes.

Our findings suggest that preventing postoperative carpal collapse relies more on maintaining the preoperative integrity of the proximal carpal row, particularly lunate height, rather than solely on capitate shortening and arthrodesis at the third metacarpal base. This aligns with Okamoto *et al*. [21] and Hegazy *et al*. [19], who linked the failure of capitate shortening to stop carpal collapse with scaphoid flexion, likely due to pre-existing lunate collapse in stage IIIA. Notably, treatment failure occurred in 40% of stage IIIA patients, who had the lowest postoperative lunate height ratios and progressed to stage IIIB after surgery.

Extensive research has utilized radial osteotomies for treating stage II or IIIA patients with neutral or positive ulnar variance [22]. These studies reported significant, long-lasting improvements in grip strength, range of motion, and pain relief. While minor arthritic changes were observed at final follow-up, they did not impact overall outcomes. Conversely, distal capitate shortening combined with arthrodesis at the third metacarpal base showed no evidence of arthritic changes, despite a shorter follow-up period compared to earlier studies.

Direct revascularization techniques have been applied to stage II and III Kienböck's disease [23]. Research has explored the effectiveness of combining revascularization with methods that reduce the load on the lunate, such as capitate shortening, radial osteotomy, external fixation, and intercarpal pinning [24]. Waitayawinyu *et al*. [25] combined capitate shortening osteotomy with vascularized bone grafting in stage II and IIIA Kienböck's patients, particularly those with neutral or positive ulnar variance. Their study highlighted significant improvements in grip strength, range of motion, and carpal height preservation, supporting the use of revascularization with unloading techniques in treating stage IIIA Kienböck's disease in similar cases.

Furthermore, SCA has been employed by numerous authors to resolve stage IIIA, consistently demonstrating substantial reductions in discomfort and enhancements in grip strength and range of motion [26].

The study's limitations include a relatively small sample size and short follow-up period, which may affect the generalizability of the results. Additionally, the lack of a control group limits the ability to compare outcomes with alternative treatments.

Conclusion

Distal capitate shortening combined with capitometacarpal arthrodesis is effective in managing stage II Kienböck's disease, significantly improving postoperative pain, ROM, grip strength, and MMWS. However, the technique demonstrates limited efficacy in halting carpal collapse in stage IIIA cases, with a higher failure rate and inadequate symptom relief. Therefore, this surgical approach is not recommended for stage IIIA Kienböck's disease. The lunate height ratio may serve as a useful prognostic indicator for the success of this intervention.

Conflict of Interest

Not available

Financial Support

Not available

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